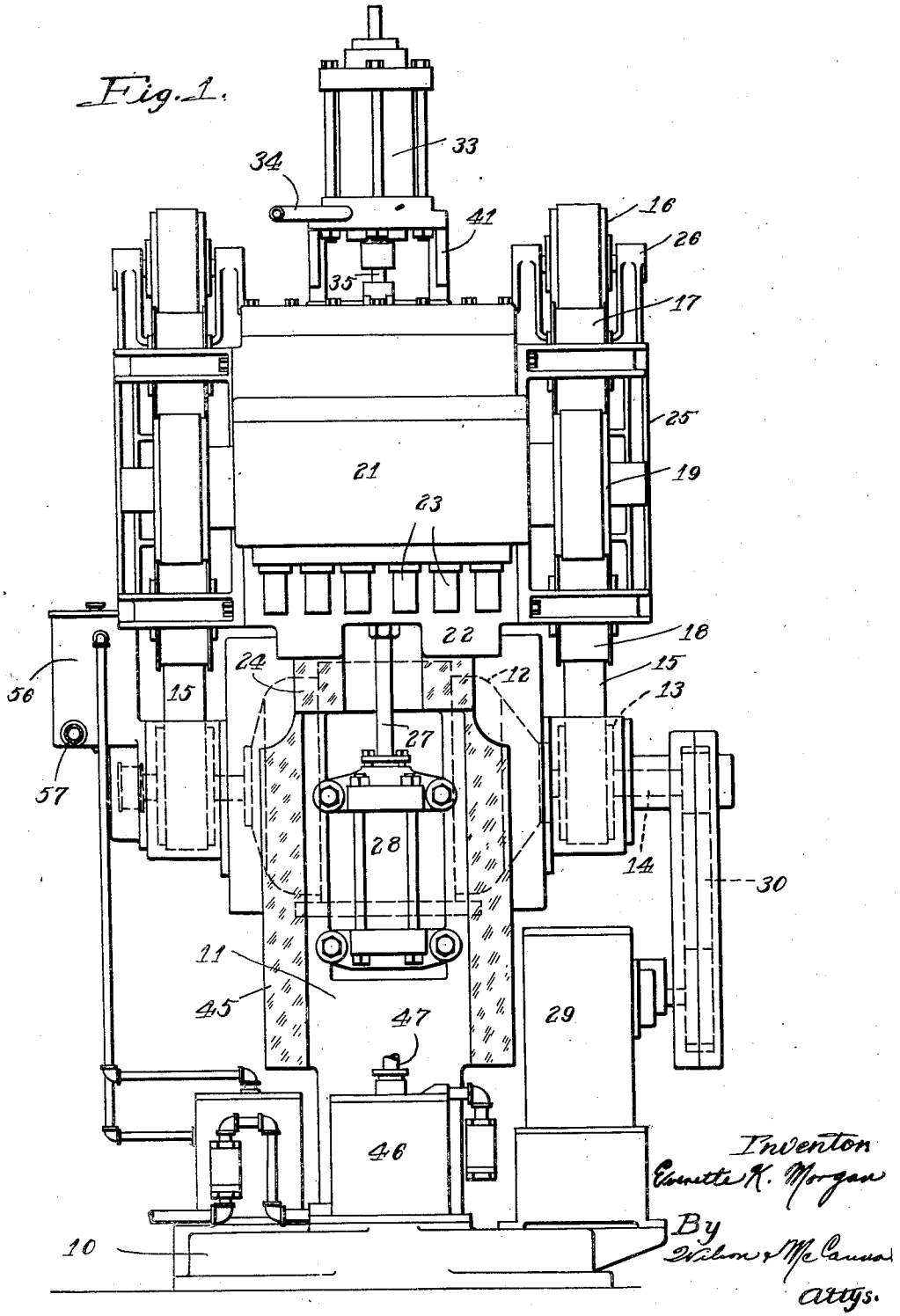
Sept. 11, 1934. E. K. MORGAN 1,973,150

HYDRAULIC MACHINE TOOL

Original Filed Nov. 19, 1926 4 Sheets-Sheet 1

Fig. 1.



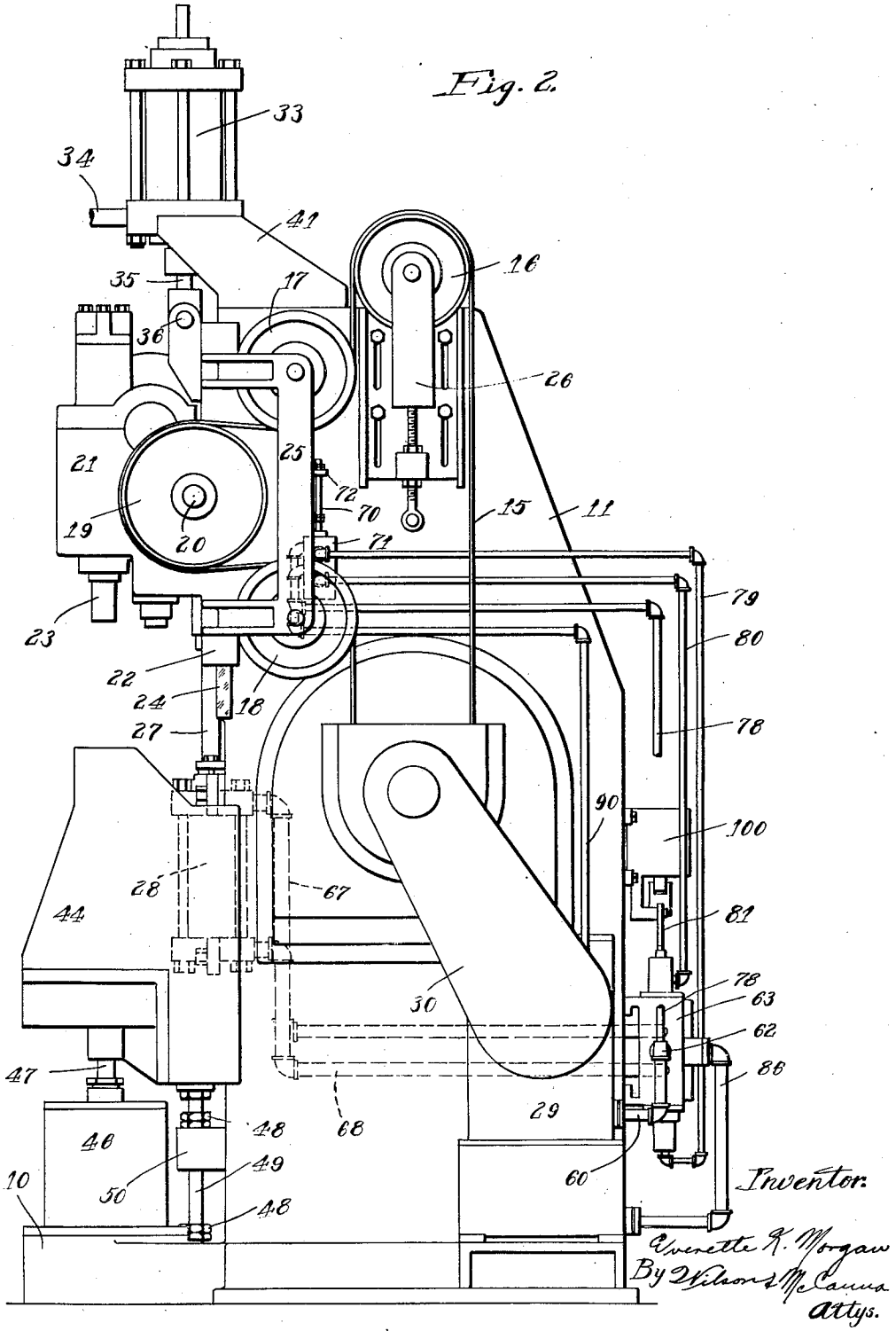
Inventon
Ernette K. Morgan
By
Wilson & McCamant
attys.

Sept. 11, 1934. E. K. MORGAN 1,973,150

HYDRAULIC MACHINE TOOL

Original Filed Nov. 19, 1926 4 Sheets-Sheet 2

Fig. 2.



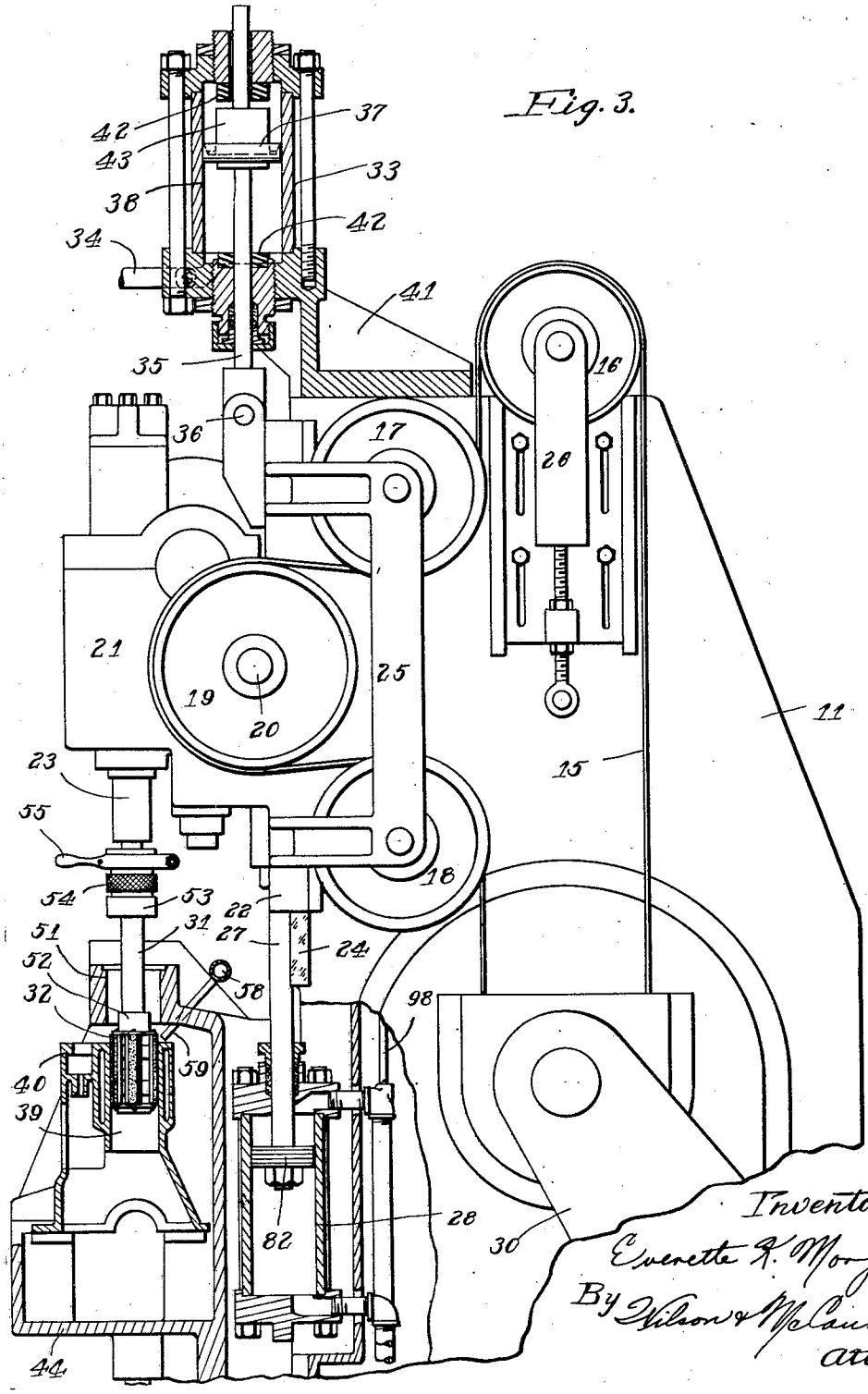
Inventor:
Everette K. Morgan
By Wilson & McCanna
Attys.

Sept. 11, 1934. E. K. MORGAN 1,973,150

HYDRAULIC MACHINE TOOL

Original Filed Nov. 19, 1926 4 Sheets-Sheet 3

Fig. 3.



Inventor:
Everette K. Morgan
By Wilson & McCanna
Attys.

Sept. 11, 1934. E. K. MORGAN 1,973,150

HYDRAULIC MACHINE TOOL

Original Filed Nov. 19, 1926 4 Sheets-Sheet 4

Fig. 4.

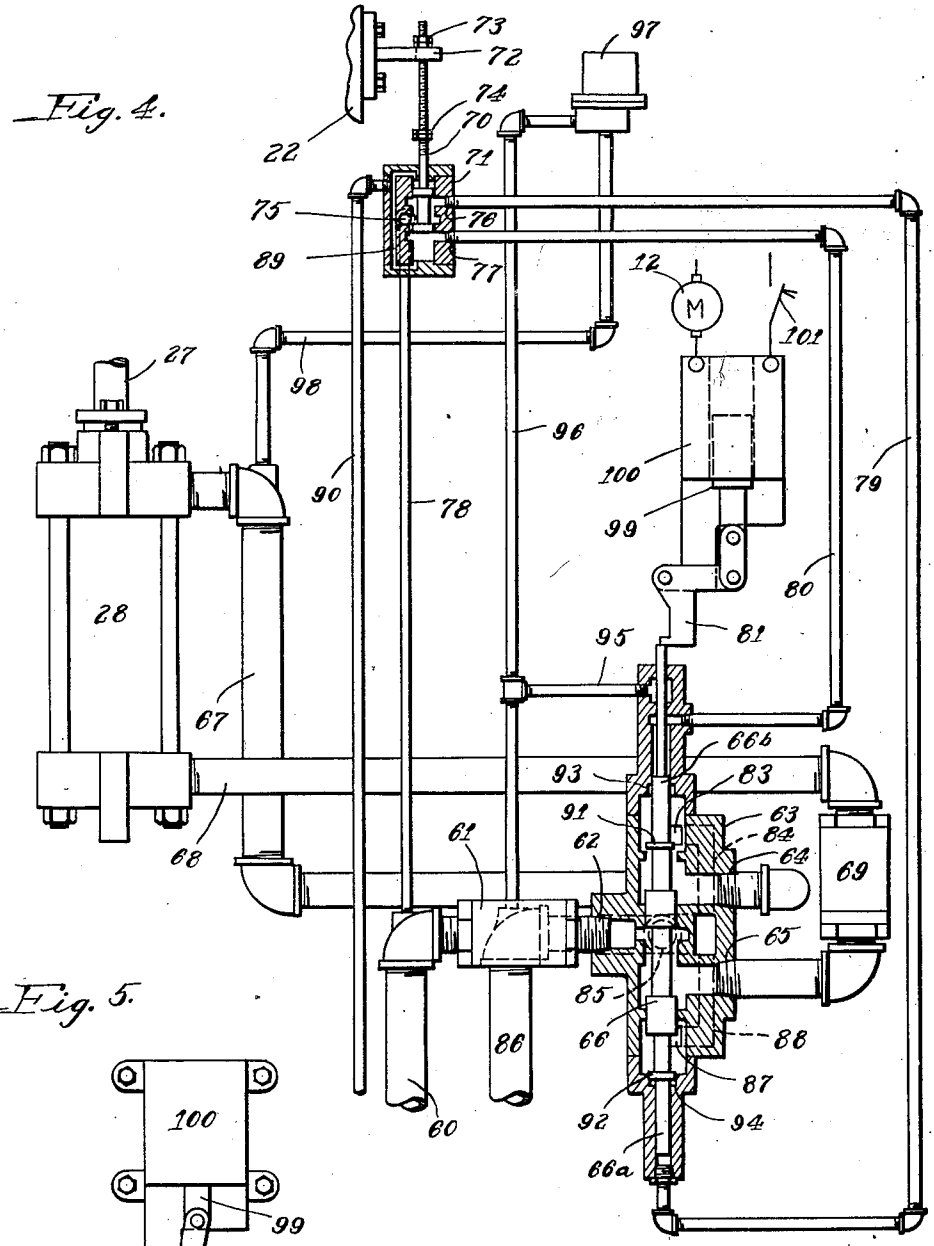


Fig. 5.

Inventon

Everette K. Morgan

By Wilson & McCanna

Attys.

Patented Sept. 11, 1934 1,973,150

UNITED STATES PATENT OFFICE

1,973,150

HYDRAULIC MACHINE TOOL

Everette K. Morgan, Rockford, Ill., assignor to The Ingersoll Milling Machine Company, Rockford, Ill., a corporation of Illinois

Application November 19, 1926, Serial No. 149,313
Renewed February 12, 1934

21 Claims. (Cl. 51—34)

This invention relates to fluid operated machine tools generally, but is more particularly concerned with a hydraulically operated bore finishing machine for performing what is interchangeably called a honing, lapping, or grinding operation on engine cylinder bores.

The principal object of the invention consists in providing hydraulically operated means to communicate reciprocatory movement to the honing tools in the cylinder bores while the tools are simultaneously revolved, there being a definite relationship between the number of reciprocations and the number of revolutions of the tools and the reciprocations being caused to die out at the same time with the revolutions, the reciprocations dying out at the upper end of the stroke.

According to the present invention, I provide in connection with the hydraulically operated tool reciprocating means, a novel hydraulic control system having a main control valve to determine by its position the direction of movement of the honing tools, and a pilot valve shiftable at the ends of the strokes of the tools to cause the shifting of the main valve to reverse the direction of travel of the honing tools. This system provides for the support of the saddle with its honing tools in a terminal raised position and also provides for the shifting of the main valve and the holding thereof in position corresponding to the raised or retracted position of the honing tools when the machine is being stopped at the close of a bore finishing operation in a cylinder block. There is also provided an adjustment in the connection between the pilot valve and the reciprocating saddle whereby the length of the stroke of the honing tools may be varied to suit any given requirements, or the operating elevation thereof may be changed.

Other objects and advantages of the present invention, having to do with matters of construction or arrangement in the machine, will be explained fully along with the above in the course of the following specification in which reference is made to the accompanying drawings showing one practical embodiment, wherein—

Figure 1 is a front view of a bore finishing machine constructed in accordance with my invention, in which the fixture for holding an engine cylinder block and the honing tools to operate in the bores of the cylinder block have been removed;

Fig. 2 is a side view showing the piping for the hydraulic system in more or less complete detail;

Fig. 3 is an enlarged view of the upper portion of Fig. 2 with certain parts appearing in vertical section for the purposes of better illustration and showing a honing tool on one of the tool spindles arranged for operation in a bore of an engine cylinder block carried on the work fixture;

Fig. 4 is a diagram of the hydraulic system on an enlarged scale showing the main valve and the pilot valve in section and also showing the relationship between the hydraulic system and the electrical control for the motor which drives the honing tools; and

Fig. 5 is an isolated detail view to show the method of operation of the solenoid operated latch appearing in Fig. 4.

Throughout the views, the same reference numerals are applied to corresponding parts.

The present machine, while particularly designed and intended for use in the finishing of engine cylinder bores, might with very little reorganization of the parts thereof be adapted for various other kinds of work wherever reciprocation or revolution or combined reciprocation and revolution of a tool is desired. Accordingly, it should be understood that no limitation is to be considered to be imposed on the application of the present invention by mere reason of the fact of the particular embodiment or application herein illustrated and described.

The present machine is of massive construction for heavy duty purposes and has a base 10 supporting a vertical column 11. The column is of hollow construction to provide a place therein for mounting an electric motor 12. Pulleys 13 are mounted on opposite ends of the armature shaft 14 of the motor 12 and have belts 15 passing about the same and threaded over idlers 16, 17, and 18 to drive pulleys 19. The latter are mounted on the ends of a cross shaft 20 received in bearings in the housing 21 provided on the saddle 22. A cluster of gears associated with tool spindles 23 is provided in the housing 21 and are driven by bevel gears meshing with bevel gears driven by the shaft 20. The driving connections are not shown in detail inasmuch as this type of drive is commonly used in machine tools employing a multiplicity of spindles. The saddle 22 is mounted for reciprocation vertically on ways 24 provided on the front of the column 11. Both pairs of idler pulleys 17 and 18 are carried by the saddle on brackets 25 so as to move therewith in the rapid up and down movement of the saddle. The idler pulleys 16 are vertically and separately adjustable with respect to the column 11 on brackets 26, in the manner indicated, and serve to take up any undue amount of slack in the belts 15. The pulley 19 is, therefore, always in driving relation with

the pulley 13 regardless of the position of the saddle 22. It will thus appear that I have provided a well-balanced and symmetrical design for accomplishing the driving of the bank of tool spindles 23 from the single motor 12 mounted in the column 11. The power take-off from both ends of the armature shaft eliminates the excessive twisting strains incident to a one-sided drive and minimizes vibration and consequent noise, wear and tear.

The spindles 23 are given a reciprocating motion simultaneous with the revolution thereof by hydraulically operated means, to be presently described, asscciated with the piston rod 27 and hydraulic cylinder 28. The hydraulically operated means derives its supply of oil under pressure from a pump 29 mounted on the base 10. The latter has a suitable chain drive connection with one end of the armature shaft 14, as shown at 30. The purpose in this is to operate the pump to furnish the oil or other pressure fluid medium at a rate bearing a direct relationship to the speed of operation of the tool spindles 23. In other words, the number of reciprocations is a factor of the number of revolutions of the tools and, as will hereinafter appear, I provide for the dying out of the reciprocations and revolutions at the same time, the reciprocations being caused to die out at the upper end of the stroke. Although no limitation as to the application of the machine is to be thereby inferred, it might be stated that the present machine has the spindles driven at approximately 280 R. P. M. while they are simultaneously reciprocated thrcugh seventy cycles per minute, thus giving the spindles two turns for each stroke up or down. I will now describe a feature of the present machine which permits of the quick reversal in the direction of travel of the saddle 22 with its operating piston 27 to which it is connected. The elimination of any lagging of the saddle 22 at the ends of the strokes is important, since it avoids the likelihood of forming the ends of the bores bell-mouthed.

The mass of the saddle 22 with its set of pulleys and other parts moving therewith, such as the flexible spindles 31 coupled to the spindles 23, as shown in Fig. 3, and the honing tools 32 carried thereby, is counter-balanced by a fluid type balancer 33 with a view to eliminating the inertia factor which would be introduced if a counterweight sufficient for the purpose were provided. The balancer 33 in the present case is connected by a pipe 34 leading to an air pressure line. A piston rod 35 fixed to the upper end of the saddle 22 as at 36, has a piston 37 operating in the cylinder 38 of the balancer. The pipe 34 communicates with the lower end of the cylinder 38 and furnishes compressed air under a pressure sufficient to place the saddle and its appurtenant parts substantially in floating relation to the column of the machine. In other words, the only load imposed on the hydraulic piston rod 27 in moving the saddle 22 up and down is the friction of the saddle on its ways and the friction of the honing tools 32 in the bores 39 of the engine cylinder block 40. The additional load imposed in reversing the direction of movement, due to inertia effects, depends only on the mass of the saddle and its appurtenant parts and not the additional mass of a counter-weight sufficient to counter-balance the saddle and the parts moving therewith. I am, therefore, enabled to reverse the direction of travel quickly and without enough lag to result in the bore becoming bell-mouthed at the ends. The speed of travel of the honing tools in the cylinder bores is, therefore, hardly any different at the ends of the strokes. In the up and down travel of the saddle, there is hardly any appreciable variation in the lift of the pneumatic piston rod 35 as the comparatively small volume of displacement in the cylinder 38 is not appreciable as compared with the volume in the compressed air reservoir and the line extending therefrom to the cylinder. The balancer 33, it will be noted, is fixed to the top of the column 11 as by means of a bracket 41 and any possible jarring, due to the piston 37 coming into engagement with the ends of the cylinder 38 at the ends of the strokes of the saddle, will be assumed by the bracket 41. In order to minimize the shock and jar and avoid noisy operation, I provide buffer pads 42 suitably of rubber or other cushioning material to be engaged by the opposite ends of the hub portion 43 of the piston 37 when the latter arrives at either end of the cylinder. If desired, however, any other fluid or mechanical type of cushioning means may be employed.

The work, in the present case a cylinder block 40, is carried on a work holding fixture 44 suitably mounted for vertical movement toward and away from the saddle 22 on ways 45 provided on the front of the column 11. While any suitable means may be employed for raising and lowering the fixture, I prefer to employ an air cylinder 46 having suitable connections with the same source of air supply as the balancer 33. A plunger 47 operating in the cylinder 46 serves to raise and lower the fixture and the position thereof is controlled by the operator who has a control valve for this purpose. The travel of the fixture up or down is determined by the setting of stops 48 on a rod 49 moving up and down with the fixture and passing through an opening in a boss 50 projecting from the front of the column 11. The fixture is shown in its lowered position in Fig. 2 preparatory to the unloading or loading of a cylinder block. The fixture is in raised position Fig. 3 for the operation of the honing tools 32 in the bores 39 of the block 40. The fixture provides dowels or other suitable locating means for positioning the work and other means is provided for clamping the work when positioned. The guide openings 51, of which there are six to correspond to the number of cylinder bores and the number of honing tools 32, serve as guides in which the tools 32 are held in proper alignment for entrance into the cylinder bores when the fixture 44 is raised from its lowered position to the working position shown in Fig. 3. The guide openings 51 are required since the mounting of the tools 32 is necessarily a flexible one as the honing tools have the stones thereof urged yieldingly into engagement with the walls of the cylinder bores under uniform pressure and the tools, to operate properly, must follow the line of the bores. The type of tool illustrated in Fig. 3 is a modified form of Hutto lap and has the stones of carborundum. Joints are provided at 52 and 53 in the connections of each of the spindles 31 with the tools 32 and the spindles 23. The knurled member at 54 is used in retracting the stones when the honing tool is contracted out of operative relation to the bore while the hand clutch, shown at 55, provides for the expanding of the tools into operative engagement in the bores. Provision is also made for the lubrication or washing of the bores with a cutting fluid such as kerosene. The fluid is supplied from a gravity

tank, shown at 56, through a pipe or hose connection 57 to a manifold 58 having branch pipes 59 for discharging the kerosene into the various bores of the cylinder block. In operation, the honing tools 32 are always maintained in alignment with the bores of the cylinder blocks in the guide openings 51 when the fixture 44 is lowered to the position shown in Fig. 2 for the removal of a finished block and the substitution of a new block. As stated above, the honing tools always wind up at the upper end of their stroke when the power is shut off. The particular means employed to accomplish such operation will be described in connection with the following description of the hydraulic system. The matter of having the tools wind up at the upper end of the stroke is necessary so that the finished block may be removed without having to lower the fixture to such a point where the honing tools will be withdrawn from their guide openings.

Referring now more particularly to Figs. 2, 4, and 5, the pump 29 has the outlet or pressure side thereof connected by the pipe 60 through a back pressure or foot valve 61 with the middle port 62 of the elongated casing 63 of what will be hereinafter termed the main control valve. The communication of the port 62 with either one of two longitudinally displaced ports 64 and 65 is determined by the position of the valve plunger 66. The upper port 64 communicates with the upper end of the hydraulic cylinder 28 through the pipe 67, while the lower port 65 communicates with the lower end of the cylinder 28 through the pipe 68. A back pressure or foot valve 69 similar to the valve 61 is interposed in the pipe 68, as shown. The back pressure valve 61 serves to maintain a low pressure differential between the pipe 60 and the inside of the valve casing 63 so that there will be a predetermined pressure available in the pipe 60 even though the pressure may drop to a low value in the casing 63. The pressure in the pipe 60 is for the purpose, as will presently appear, of shifting the main valve plunger 66. The reason the pressure within the casing 63 may drop to a low value is that the pump 29 which furnishes the oil under pressure has a variable delivery, which is constant at any setting, and is capable of building up pressure to a predetermined point only as the resistance to the discharge of oil from the pump builds up. Thus, when the piston 82 in the cylinder 28 is under motion, there is less pressure in the casing 63 than at the moment when the direction of motion of the piston is reversed. The back pressure valve, under these circumstances, always reserves sufficient pressure in the pipe 60 for the actuation of the main valve plunger 66. The back pressure valve 69, on the other hand, is arranged merely to act as a check valve to avoid drainage of oil from the cylinder 28 when the machine is stopped. If the oil drained out, air would take its place and prevent proper functioning of the machine when it was again placed into operation. The construction of the valves 61 and 69 has not been shown in detail, as valves of this type are believed to be generally known and practically any standard or preferred construction may be employed. The valve plunger 66, as just above stated, is moved up and down in the casing 63 under hydraulic pressure and its position is governed by the position of the plunger 70 in the casing 71 of what will hereinafter be termed the pilot valve or auxiliary control valve. The position of the plunger 70 is in turn determined by the position of the saddle 22, by reason of the movement of the plunger 70 up or down at the upper and lower limits of the travel of the saddle when the dog 72 on the saddle engages stops 73 and 74 provided on the plunger 70. The stops 73 and 74 are adjustable to determine both the amplitude of the strokes of the saddle as well as the particular elevation at which the saddle will operate up and down. The pilot valve plunger 70 controls the communication between a middle port 75 provided in the casing 71 and two longitudinally displaced ports 76 and 77. Oil under the low predetermined pressure is supplied to the port 75 through a pipe 78 communicating with the pipe 60. The upper port 76 communicates through a pipe 79 with the lower end of the main valve casing 63 while the lower port 77 communicates through a pipe 80 with the upper end of the main valve casing. All parts appearing in Fig. 4 are illustrated in their positions corresponding to the upper terminal position of the saddle 22. Under these circumstances, the pilot valve plunger 70 is raised by the dog 72 to establish communication between the ports 75 and 76 so that oil under a low pressure is supplied to the lower end of the main valve casing 63 to operate against the piston end 66*a* of the plunger 66. The main valve plunger 66, therefore, tends to rise, as indicated in the dotted lines shown in Fig. 5, and would do so were it not for the latch 81 which holds the same down when the power has been shut off and the machine comes to a standstill. The operation of the latch 81 will be presently described. It will suffice to state at this point, however, that it is normally retracted to an inoperative position to permit the free movement of the main valve plunger 66, as indicated in Fig. 5. Before the raising of the main valve plunger 66, due to the raising of the pilot valve plunger 70 by the dog 72, as just above described, the port 62 is in communication with the port 65, as shown in Fig. 4, to furnish oil under pressure to the lower end of the cylinder 28 to elevate the saddle. When the plunger 66 is raised in the normal operation of the machine, communication is established between the ports 62 and 64 so that oil is supplied under pressure to the upper end of the cylinder 28 to lower the saddle. It will, therefore, appear that the operation of the pilot valve plunger at the limit of its up or down strokes produces the reversal in direction of travel of the saddle by correspondingly shifting the main valve plunger. For example, at the lower end of the stroke, the dog 72 engages the stop 74 and shifts the pilot valve plunger 70 so that communication is established between the ports 75 and 77 and oil under a low pressure is supplied to the upper end of the main valve casing 63 to operate against the piston end 66*b* of the main valve plunger 66 to shift the same down to the position shown in Fig. 4. This immediately establishes communication between the port 62 and the port 65 and oil under pressure is supplied to the lower end of the cylinder 28 to again elevate the saddle. This description is believed to make it clear that the length of the stroke of the saddle is determined by the setting of the stops on the pilot valve plunger and that the saddle may be made to operate up and down at different elevations.

Provision is made on the main valve casing 63 for returning oil to the pump in the repeated reversing in the direction of travel of the piston 82 in the hydraulic cylinder 28. When commu-

nication is established between the ports 62 and 65 for elevating the saddle, communication is established between the other port 64 and a port 83 communicating through a passage 84 with a drain port 85 which has a pipe 86 leading therefrom to the return side of the pump 29. When the position of the main valve plunger is changed to establish communication between the ports 62 and 64, the port 65 is placed into communication with a port 87 also leading by way of a passage 88 to the drain port 85. Thus the oil in front of the piston 82 is afforded an outlet to the return side of the pump as the piston 82 is alternately moved up and down. A similar provision to that just described is made in the case of the pilot valve where a passage 89 which discharges through a drain pipe 90 to the return side of the pump 29 is alternately placed into communication with the ports 76 and 77 as the pilot valve plunger 70 is shifted to and fro.

The operation of the main valve plunger 66 goes on at a rapid rate and reverses the direction of travel of the piston 82 as many as one hundred forty times per minute, as stated above. The plunger is arranged to be cushioned at the limits of its movements in the casing 63 when the small piston portions thereon, shown at 91 and 92, are moved into short cylindrical bores 93 and 94 provided therefor within the casing 63, as shown. The operation of the valve is, therefore, smooth and quiet and the valve will require practically no attention after installation. Where the plunger 66 projects from the end of the casing 63, I provide a drain outlet 95 leading to the drain pipe 86. This avoids the necessity for providing the usual form of packing which might in time require renewal or, at any rate, some attention. Also communicating with the drain pipe is a pipe 96 leading from an air leak unit 97. The latter is preferably of the conventional capillary tube type. A pipe 98 leads from the highest point of the hydraulic cylinder 28 to the air leak unit 97 so that any air which may be injected into the system will have an opportunity to seep out.

As shown in Fig. 4, the latch 81 is operated by the armature 99 of a solenoid 100. The coil of the solenoid is connected in series with the motor 12 and a switch 101 which controls the turning on and off of the motor. In operation, when the switch 101 is closed to start the motor 12, the latch 81 is withdrawn to an inoperative position, as shown in Fig. 5. Thus, the main valve plunger 66 is allowed freedom of movement and the reciprocation of the saddle will commence. The operator, by manipulation of the clutches 55, expands the honing tools to operate in the bores of the cylinder block to finish the same. Due to the simultaneous revolution and reciprocation of the tools, the "fuzzy" surfaces of the bores are smoothed in the course of about two minutes operation. Obviously, a considerable saving in time results in the use of the present machine, as a finishing operation as previously done required as much as forty minutes or more to complete. The operator goes over the set of clutches 55 from time to time as the finishing of the bores proceeds so as to make sure that the stones are having the proper purchase in the bores and the bores will be finished uniformly. At the close of the finishing operation, the operator opens the switch 101 to shut off the motor. This allows the latch 81 to fall into its operative position, as shown in Fig. 4. Thus when the plunger 66 is shifted to its lowermost position the latch 81 moves into a position preventing the return of the plunger, substantially as shown. Inasmuch as the main valve plunger 66 is lowered at the extreme upper position of the saddle, and the latch 81 prevents the plunger from rising to lower the saddle, the saddle will be left in a terminal raised position. In case there is any tendency for the motor 12 to overrun due to the momentum of the armature, the pulleys and other rotating parts, which would result in the honing tools 32 producing a circular scratch at the upper end of the cylinder bores, the motor 12 may be equipped with a dynamic brake, or a solenoid controlled brake, or one operating mechanically may be provided to insure the simultaneous dying out of the rotations with the reciprocations of the honing tools. After the completion of the finishing operation, the stones of the honing tools may be retracted by operation of the knurled collars 54, whereupon the fixture 44 may be lowered to permit withdrawal of the finished block and the substitution of another block. While a new block is being substituted, the honing tools will obviously be kept from displacement from their proper positions by their having been caused to enter the guide openings 51 in the lowering of the fixture. Thus, when the fixture is raised, the honing tools are entered properly into the several cylinder bores.

If desired, the operation of the machine may be varied from the above method to this extent: The motor 12 may be stopped at any point regardless of the position of the tools 32. Thereupon, the stones may be retracted, as in the other case, and the motor caused to turn over a few turns sufficient to pump enough oil to bring the saddle to the upper terminal position. The contracting of the honing tools in the bores will permit the rotation thereof freely without any danger of producing circular scratches. Then the fixture may be lowered to remove the finished block and substitute another block as before.

It is believed that the foregoing conveys a clear understanding of the present invention and of its various objects and advantages. It will be understood that the invention is not to be considered as limited to the particular details of construction and arrangement herein shown and described; the machine is capable of a considerable range of variation without departing seriously from the general scope and spirit of the invention as covered in the appended claims.

I claim:

1. In a machine, such as a lapping machine, comprising a reciprocating carriage, fluid operated means such as a piston for reciprocating the same, a pump serving as a source of pressure fluid supply, means for driving the pump, a main valve for alternately establishing communication between said source and opposite sides of the operating piston whereby to move the carriage back and forth, a pilot valve operated by the carriage controlling auxiliary communication between said source and said main valve whereby to shift the latter at the ends of the strokes of the carriage, and means arranged to hold the main valve in a certain predetermined position whereby correspondingly to prevent movement of the carriage from a predetermined position, said means being operatively connected with the pump driving means to hold said valve automatically immediately after the driving means ceases to operate and when the valve reaches the predetermined position, whereby to

predetermine the stopping point of the carriage.

2. In a machine, such as a lapping machine, or the like, comprising a reciprocable tool carrier, fluid operated means such as a piston for reciprocating the same, a pump serving as a source of pressure fluid supply, an electric motor for driving said pump and also the tool or tools on the tool carrier, valve means for alternately establishing communication between said source and opposite sides of the operating piston to move the carrier back and forth, said valve means being operated back and forth by the carrier at the ends of the strokes thereof, and means arranged to lock the valve means in a terminal position whereby to prevent movement of the tool carrier from a terminal position, said means being held in an inoperative position during the operation of said electric motor but being arranged upon interruption of the current to said motor to be brought into operative position to hold the valve means in terminal position.

3. In a machine as set forth in claim 2 wherein the valve means comprises a main valve for alternately establishing communication between the source and opposite sides of the operating piston, and a pilot valve operated by the tool carrier controlling auxiliary communication between said source and the main valve to operate the latter by fluid pressure at the ends of the strokes of the tool carrier to reverse the direction of movement of the latter, the means for holding the valve means in terminal position comprising a latch cooperating with the main valve, a solenoid included in the circuit of the electric motor having the armature thereof connected with the latch to operate the same.

4. In a machine, such as a lapping machine or the like, comprising a vertically reciprocable tool carrier, fluid operated means such as a piston for reciprocating said carrier, a pump serving as a source of pressure fluid supply, an electric motor for driving said pump and also the tool or tools on said carrier, a main valve shiftable between two terminal positions for alternately establishing communication between the source and opposite sides of the piston to move the carrier up and down, a pilot valve operated from one terminal position to another by the tool carrier at the ends of the strokes thereof and serving to control auxiliary communication between the source and the main valve to shift the latter by fluid pressure, a latch movable from an inoperative to an operative position to hold the main valve in one of its terminal positions corresponding to the raised position of the tool carrier, a switch for interrupting the circuit for the electric motor, and a solenoid included in the motor circuit having the armature thereof connected with said latch and serving normally to hold the latter in inoperative position.

5. In a machine of the character described, a reciprocating tool carrier carrying a revolving tool, means for driving said tool, another means for simultaneously reciprocating the same, the last mentioned means having a control member movable to and from a terminal position at which the tool carrier is at the end of its stroke, and means cooperating with said control member whereby the driving and reciprocating means operate in unison and whereby they automatically stop at the same time with the tool carrier brought to the end of its working stroke.

6. In a machine of the character described, a reciprocating tool carrier carrying a revolving tool, electrically operated means for driving said tool, the same having a control member for throwing it into and out of operation, other means driven by the electrically operated means for reciprocating the tool with its carrier, the latter means having a control member movable to and from a terminal position at which the tool carrier is at the end of its stroke, and means interconnecting the control members of the two means whereby when the electrically operated means is stopped the tool carrier reciprocating means will be caused automatically to stop simultaneously therewith with the tool carrier at the end of its working stroke.

7. In a machine of the character described, a vertically reciprocating tool carrier carrying a revolving tool, a work support in relation to which the tool carrier is movable up and down to be advanced and retracted with respect to a piece of work, electrically operated means for driving the revolving tool, fluid operated means for reciprocating the tool carrier, said fluid operated means being operated by said electrically operated means to synchronize the reciprocation of the carrier with the revolution of the tool thereof, a valve shiftable to and fro to produce the up and down reciprocation of the carrier, and an electrical control for said electrically operated means having a part arranged when the electrically operated means is shut off to hold the valve in a terminal position corresponding to the elevated position of the carrier with the tool thereof retracted with respect to the work.

8. In a machine tool the combination of a reciprocating carriage, a revolving spindle or the like, an electrically operated means for driving the revolving spindle, fluid operated means for reciprocating the carriage, said fluid operated means being operated by said electrically operated means to synchronize the reciprocation of the carriage with the revolving of the spindle, a valve shiftable to and fro to produce the reciprocation of the carriage, and an electrical control for said electrically operated means having a part arranged when the electrically operated means is shut off to hold the valve in a terminal position corresponding to the terminal position of the carriage.

9. In a machine tool the combination of a reciprocating carriage, fluid operated means such as a piston for reciprocating the same, a pump serving as a source of pressure fluid supply, means for driving the pump, a main valve for alternately establishing communication between said source and opposite sides of the piston whereby to move the carriage back and forth, a pilot valve operated by the carriage controlling auxiliary communication between said source and said main valve whereby to shift the latter at the ends of the strokes of the carriage, and means arranged to hold the one valve in a certain predetermined position whereby correspondingly to hold the carriage in a predetermined position, said means being operatively connected with the pump driving means to hold said valve automatically immediately after the driving means ceases to operate and when the valve reaches the predetermined position, whereby to predetermine the stopping point of the carriage.

10. In a machine tool the combination of a reciprocating carriage, fluid operated means such as a piston for reciprocating the same, a pump serving as a source of pressure fluid supply, means for driving the pump, a main valve for alternately establishing communication between said source and opposite sides of the piston whereby to

move the carriage back and forth, a pilot valve operated by the carriage controlling auxiliary communication between said source and said main valve whereby to shift the latter at the ends of the strokes of the carriage, and means arranged to hold the main valve in a terminal position, whereby to prevent movement of the carriage from a corresponding terminal position, said means being operatively connected with the pump driving means to hold said valve automatically immediately after the driving means ceases to operate and when the valve reaches the terminal position, whereby to predetermine the stopping point of the carriage.

11. In a machine tool the combination of a reciprocable carriage, a revolving spindle or the like, fluid operated means such as a piston for reciprocating the carriage, a pump serving as a source of pressure fluid supply, an electric motor for driving said pump and also said spindle or spindles, valve means for alternately establishing communication between said source and opposite sides of the piston to move the carriage back and forth, said valve means being operated back and forth by the carriage at the ends of its strokes, and means arranged to lock the valve means in a terminal position whereby to prevent movement of the carriage from a terminal position, said means being held in an inoperative position during the operation of said electric motor but being arranged upon interruption of the current to said motor to be brought into operative position to hold the valve means in terminal position.

12. A machine tool as set forth in claim 11 wherein the valve means comprises a main valve for alternately establishing communication between the source and opposite sides of the operating piston, and a pilot valve operated by the carriage controlling auxiliary communication between said source and the main valve to operate the latter by fluid pressure at the ends of the strokes of the carriage to reverse the direction of movement of the latter, the means for holding the valve means in a terminal position comprising a latch cooperating with one of the aforesaid valves, and a solenoid included in the circuit of the electric motor having the armature thereof connected with the latch to operate the same.

13. A machine tool as set forth in claim 11 wherein the valve means comprises a main valve for alternately establishing communication between the source and opposite sides of the operating piston, and a pilot valve operated by the carriage controlling auxiliary communication between said source and the main valve to operate the latter by fluid pressure at the ends of the strokes of the carriage to reverse the direction of movement of the latter, the means for holding the valve means in terminal position comprising a latch cooperating with the main valve, and a solenoid included in the circuit of the electric motor having the armature thereof connected with the latch to operate the same.

14. In a machine tool the combination of a reciprocable carriage carrying a revolving spindle or the like, fluid operated means such as a piston for reciprocating said carriage, a pump serving as a source of pressure fluid supply, an electric motor for driving said pump and the aforesaid spindle or spindles, a main valve shiftable between two terminal positions and alternately establishing communication between the source and opposite sides of the piston to move the carriage back and forth, a pilot valve operated from one terminal position to another by the carriage at the ends of the strokes thereof and serving to control auxiliary communication between the source and the main valve to shift the latter by fluid pressure, a latch movable from an inoperative to an operative position to hold the main valve in one of its terminal positions corresponding to a terminal position of the carriage, a switch for interrupting the circuit for the electric motor, and a solenoid included in the motor circuit having the armature thereof connected with said latch and serving normally to hold the latter in inoperative position.

15. In a machine tool, the combination of an upright column, the same providing vertical guides thereon, a carriage reciprocable vertically on said guides having one or more spindles carried thereby, means arranged to communicate reciprocation to the carriage, an electric motor disposed on the column with the opposite ends of the armature shaft thereof extending from opposite sides of the column, there being pulleys on the ends of said shaft and other pulleys in alignment therewith mounted on the column, with belts passing over the same on opposite sides of the column, and the carriage having spindle drive pulleys on opposite sides thereof contacting with the belts to be driven thereby.

16. In a machine tool as set forth in claim 15 wherein the means for reciprocating the carriage comprises, a working cylinder element, and a piston element cooperating therewith, the one element having connection with the carriage to reciprocate the latter, and a pump serving as the source of pressure fluid supply arranged to communicate with the cylinder alternately on opposite sides of the piston, means for driving the pump off one end of the motor armature shaft whereby to synchronize the reciprocation of the carriage with the turning of the spindles.

17. In a machine tool, the combination of a reciprocable carriage carrying a revolving spindle or the like, means for reciprocating the carriage comprising a working cylinder element and a piston element cooperating therewith, the one element having connection with the carriage to reciprocate the latter, a pump serving as a source of pressure fluid supply, and valve means for establishing communication between said pump and said cylinder alternately on opposite sides of the piston, a prime mover, means providing an operating connection between the prime mover and the revolving spindle to turn the same, and means providing an operating connection between the same prime mover and the aforesaid pump, whereby to synchronize the reciprocation of the spindle with the turning thereof so that the number of reciprocations is a factor of the number of revolutions.

18. In a machine such as a lapping machine, comprising a vertically reciprocating carriage, fluid operated means such as a piston for reciprocating the same, a pump serving as a source of pressure fluid supply, means for driving the pump, a main valve for alternately establishing communication between said source and the opposite sides of the operating piston whereby to move the carriage up and down, a pilot valve operated by the carriage controlling auxiliary communication between said source and said main valve whereby to shift the latter at the upper and lower ends of the strokes of the carriage, and means for holding the main valve in a terminal position whereby correspondingly to prevent downward movement of the carriage from a

raised terminal position, said means being operatively connected with the pump driving means to hold said valve automatically immediately after the driving means ceases to operate and when the valve reaches the terminal position, whereby to predetermine the stopping point of the carriage.

19. In a machine tool the combination of a reciprocating carriage, fluid operated means such as a piston for reciprocating the same, a pump serving as a source of pressure fluid supply, means for driving the pump, a main valve for alternately establishing communication between said source and opposite sides of the piston whereby to move the carriage back and forth, a pilot valve operated by the carriage controlling auxiliary communication between said source and said main valve whereby to shift the latter at the ends of the strokes of the carriage, a manually operable control for the pump driving means for starting and stopping the pump at will, and means to hold the one valve in a predetermined terminal position and correspondingly hold the carriage in a certain terminal position, said means being operatively connected with the pump driving means to hold said valve automatically immediately after the driving means ceases to operate and when the valve reaches the terminal position, whereby to predetermine the stopping point of the carriage.

20. In a machine tool the combination of a reciprocating carriage, fluid operated means such as a piston for reciprocating the same, a pump serving as a source of pressure fluid supply, means for driving the pump, a main valve for alternately establishing communication between said source and opposite sides of the piston whereby to move the carriage back and forth, a pilot valve operated by the carriage controlling auxiliary communication between said source and said main valve whereby to shift the latter at the ends of the strokes of the carriage, a manually operable control for the pump driving means for starting and stopping same at will, and means to hold the one valve in a certain predetermined position and hold the carriage in a certain position, said means being operatively connected with the pump driving means to hold said valve automatically immediately after the driving means ceases to operate and when the valve reaches the predetermined position, whereby to predetermine the stopping point of the carriage.

21. In a machine tool, the combination of an upright column the same providing vertical guides thereon, a carriage reciprocable vertically on said guides having one or more spindles carried thereby, means arranged to communicate reciprocation to the carriage, said means comprising a working cylinder element and a piston element cooperating therewith, the one element having connection with the carriage to reciprocate the latter, a pump serving as the source of pressure fluid supply, and valve means for establishing communication between said pump and said cylinder automatically on opposite sides of piston, an electric motor disposed on the column with the end of the armature shaft extending laterally from the column, there being a pulley on said shaft and another pulley in alignment therewith mounted on the column, with a belt passing over the same, and the carriage having a spindle drive pulley on the side thereof contacting with the belt to be driven thereby, whereby to transmit drive to the spindles during the reciprocation of the carriage, and means for driving the pump off one end of the motor armature shaft whereby to synchronize the reciprocation of the carriage with the turning of the spindles.

EVERETTE K. MORGAN.